Approximately 80 to 85 percent of the annual precipitation occurs during the seven months from October through April in Western Washington. The driest months are typically July and August. Above 2,500 to 3,000 feet, precipitation generally falls as snow from about November through March. Maximum snow accumulations in higher elevations normally occur in last part of March or early April. Snow at the 5,000-foot level in Western Washington may remain into July. Snowfall decreases rapidly on the east slopes of the Cascades with increasing distance east of the crest.

The influence of the Pacific Ocean provides generally mild temperatures in Western Washington, with winter minimums of 25° to 30° F and maximums of 40° to 45° F. July is the warmest month, with maximum temperatures of 65° to 75° F in the coastal areas and 75° to 80° F inland. Minimum temperatures average near 50° F. Temperatures are more extreme in Eastern Washington because of the continental influence. January maximums average generally between 30° and 40° F and minimums between 15° and 25° F. July maximums average 85° to 90° F and minimums 45° to 55° F.

Prevailing winds are generally southwesterly over the state during late fall, winter and early spring, and northwesterly and lighter during late spring, summer and early fall.

The most intense storms take place in late fall and early winter, with wind velocities ranging from 50 to 70 mph or higher along the coast almost every winter. Speeds approaching or exceeding 100 mph have been observed occasionally on coastal ridges. Wind speeds inland are lower during these storms but have been observed at 50 to 60 mph.

Rain usually accompanies lightning storms. Western Washington has 10 to 12 storms each year, mostly along the western slopes of the Cascades. There are about 25 lightning storms each year in Eastern Washington, usually accompanied by rain but in lesser amounts. However, an outbreak of "dry lightning" occurs an average of two to three times each year in Eastern Washington and on rare occasions in Western Washington.

In Western Washington, the sun shines about 24 percent of the time in December. In July, the figure is usually about 61 percent. In Eastern Washington, the sun shines 25 to 30 percent of the time in December and January, but the figure increases to 80 to 85 percent in July/August. Frost-free days in Western Washington begin in late April and continue to early November, while in Eastern Washington the frost-free period begins in late May and ends in late September.

#### 7.3.2.3 Odor

A wide variety of odors are emitted through the natural processes of a forest ecosystem. The combination of these odors produces a very distinctive smell, generally considered pleasant. There are many subtle variations of smell in a forest, which depend on the composition of vegetative species (overstory and understory). Smells range from the fragrance of wild flowers and conifer foliage to the musty odors of decaying vegetation and bogs.

Smells vary with forest type and location in the forest, the weather and many other factors. The stage of forest succession will impact smell, (for example, certain old growth forests contain a wider floral variety than second growth forests). Wildfires also create odor in the forests. Pollution from urban areas is beginning to affect forest smells in the Puget Sound area.

### 7.3.3 **Water**

#### 7.3.3.1 Surface Water

The principal influence on surface water movement is the hydrologic regime, which refers to the combined effects on water of climate, soils, geology, topography and vegetation.

Because of topographic extremes, the state is subdivided into several hydrologic regimes which, with one exception, are the same as the physiographic provinces discussed above in the geology and topography section (see 7.3.1.1).

The one exception concerns the Cascade Mountain Range (physiographic) province, which contains two different hydrologic regions: Eastside Cascade and Westside Cascade. The Westside Cascade region is the area between the Glaciated Puget Sound Lowland Province and the crest of the Cascade Mountains. The area east from the crest to approximately 2,000 feet elevation comprises the Eastside Cascade region.

The following paragraphs contain a general discussion of water quantity, quality and temperature.

1. Surface Water Quantity

Quantity of surface water varies considerably among hydrologic regions and even within regions. By expressing average quantity of water produced annually in terms of depth per unit area, regions can be compared regardless of size. The quantity of surface water is determined by: 1) the amount of precipitation; and 2) the extent of losses to the atmosphere or to deep percolation into the ground.

Precipitation is controlled by climate and is not significantly influenced by forests or their management. Loss to the atmosphere by evaporation and transpiration of plants is a function of climate interacting with vegetation and soils. These functions are influenced by the forest condition.

Whether water that has moved through the soil will become surface flow or go into ground water aquifers depends largely on the region's geology.

Water movement in natural streams is a function of water volume, channel geometry and channel slope or gradient. In unmanaged forest areas, the most common disturbance is trees and other vegetation entering streams. In places where this debris is temporarily stabilized, flows may back up and increase in depth.

2. Surface Water Quality

The forests in Washington, for the most part, produce high quality water for human and animal use. A delicate balance exists between forest influences and several processes that can potentially degrade water quality. When this balance is disturbed, adverse effects can occur. Of the potentially degrading processes related to forest influences, sedimentation is the most important. An estimated 80 percent of water quality deterioration is associated with this process. Sedimentation includes the whole process of erosion, sediment transport and deposition. Sediment transport is the movement of the products of erosion. Deposition is the temporary or permanent stoppage of sediment movement.

Sediment must be transported to or near a water body to affect water quality. Except for channel flow, water is not a major transport mechanism in an undisturbed forest. Gravity serves as the principal means of transporting sediment to water bodies. The forest, however, is usually a stabilizing influence that minimizes the effect of sedimentation on water quality.

Surface water quality is not affected if sediment is deposited before reaching a water body. But once sediment reaches streams, deposition can occur several times over. As flow velocities and volumes increase, sediment is moved downstream. If flow volume or velocities decrease, deposition can occur. The amount of sediment suspended or moved along the stream bed therefore depends on surface water movement.

Sediment affects water quality in several ways. It creates a turbid (muddy) condition that restricts light in the stream environment. Nutrients combined with or attached to the sediment particles are added to surface water. Oxygen-demanding materials associated with sediment can reduce dissolved oxygen content. Sedimentation is also a means of introducing harmful minerals into surface water.

The high absorption capability of forest soils, combined with the uptake of vegetation, does not allow many dissolved solids to be leached and enter surface water. As a result, surface waters are usually low in dissolved solids. In the mature forest, the nutrient cycle generally approaches a steady state; only small amounts of nutrients are discharged in the drainage water. Volumes of dissolved solids are therefore usually small in streamflow from forested areas and primarily reflect the area's geology.

Streamside vegetation can also temporarily degrade surface water quality. Water quality in a small stream is often related to the amount of autumn leaves that fall into the stream channel: Dissolved oxygen and pH decreases but water color, specific conductance, iron magnesium and bicarbonate ions all increase as more leaves enter the water. (Deciduous litter, which is primarily deposited in autumn, decomposes faster than coniferous litter. Water quality is therefore affected to a greater extent by deciduous than coniferous litter.)

3. Temperature

The temperature of surface water is another quality modified by a forest. Streamside vegetation prevents extreme daily fluctuation in temperature during low flows and high energy input by providing shade and absorbing energy. With lower temperatures, dissolved oxygen concentrations are higher. Temperature is critical for the survival of various fish species, and it can also affect water quality. Algae, for example, bloom in warm water and can interfere with fish habitat and recreation. Changes in temperature as a result of timber harvesting are typically noted in small rivers and streams.

7.3.3.2 Ground Water

The term "ground water" means all water below the ground surface. It includes two types of water storage and movement: aquifers and subsurface flow.

Aquifers consist of water that has percolated through soil mantle or channel bottoms into geologic formations capable of storing water and allowing its lateral movement. In general, water movement through aquifers is slow and little affected by immediate precipitation. The presence of aquifers is determined by the geology of a region. In Western Washington, most of the area underlain by aquifers is in the Glaciated Puget Sound Lowlands province and near the coast of the Olympic Peninsula province.

In the forested areas of Eastern Washington, aquifers are mostly limited to the vicinity of the channels of major drainages. Most aquifers consist of sedimentary materials. Others include basalt formations. They are usually deep below the surface, sometimes up to several thousand feet.

Subsurface waters, on the other hand, typically enter the soil and are stopped by an impervious layer of bedrock or consolidated materials. If the land surface is on an incline, lateral movement occurs within or just below the soil. Movement is often rapid and sensitive to immediate precipitation. Subsurface flow is the most common in Washington forested areas, especially in mountainous areas. Movement of subsurface flow is determined by the topography and characteristics of soil and subsoil. Subsurface flow is also the most influenced by the forest condition and management activities.

1. Ground Water Quantity

The quantity of ground water at any time is determined by the amount of water percolating through the soil, the amount in storage below the soil surface and in aquifers, and the amount either removed for domestic purposes or entering stream channels and other surface water bodies.

Trees and plants remove water from soil by the process of transpiration. This loss of water in soil creates a moisture content that is less than the maximum amount the soil can hold. When precipitation or snowmelt are absorbed, water is held in the soil until the maximum level of moisture content is reached.

2. Ground Water Quality

Ground water quality is not as sensitive as that of surface water to forest conditions and management. In general, the quality of ground water in aquifers depends more on aquifer geology than on forest influences. Subsurface flows are more sensitive to forest influences because of their location near the surface.

Forest soils serve as excellent filters through which water percolates. Dissolved and suspended solids and organic compounds are filtered or absorbed by soil. As a result of this natural filter, ground water recharged from forest land is generally of good quality.

7.3.3.3 Runoff, Floods and Absorption

Runoff is the movement of water across soil surface until it reaches a defined stream channel, lake or pond. It moves as sheet layer across soil surface. Absorption, on the other hand, is the movement of water into soil. Floods are high or peak water flows that exceed ordinary high-water level in streams.

Runoff seldom occurs in an undisturbed forest. Absorption typically exceeds maximum rainfall intensities in Western Washington, though exceptions can occur in portions of Eastern Washington when thunderstorms produce intense rainfall.

All three types of water movement -- runoff, absorption and floods -- are sometimes influenced by the extent and timing of snowmelt.

Although snow is not a major part of the hydrologic regime of the Glaciated Puget Sound Lowlands Province, it is a dominant characteristic in the Eastside Cascade Region and the Okanogan Highlands, Blue Mountains and Columbia Basin Provinces.

"Rain-on-snow" events, as they are commonly called, illustrate the relationship between the different forms of water movement. A rain-on-snow event refers to heavy, warm rains that fall on snow packs, typically at 2,000 to 3,000 foot elevation, melting the snow quickly and sometimes dramatically increasing the flow of water as both rain and melting snow are channeled into streams and rivers. The severity of these events may be influenced by clearcutting and road construction, which may accelerate the amount and rate of water movement. Except for these rain-on snow events, extreme water flows are usually not significantly influenced by the condition of the forest.

7.3.3.4 Public Water Supplies

Forest watersheds in Washington are an important source of public water supplies, mostly from surface water supplies. The quality of surface water from state forest land is generally good, making forests a valuable source of drinking water that often requires little treatment. Activities in forest watersheds can affect public water supplies in two related ways: 1) quantity; and 2) quality, which in turn can affect the usable quantity of water.

The department manages state forest land in several major watersheds used for public water supplies, including the Sultan, Tolt and Green River Basins in Western Washington and Buck Creek watershed in Eastern Washington.

Whether the department significantly affects public water supplies depends on the proportion of watershed areas managed by the department and the type and timing of activities there.

### 7.3.4 **Land Use**

The department intends to maintain a diverse base of state forest lands. At present, the department's holdings (2.1 million acres) represent about 5 percent of the total land base in the state, and 12 percent of the total commercial forest land.

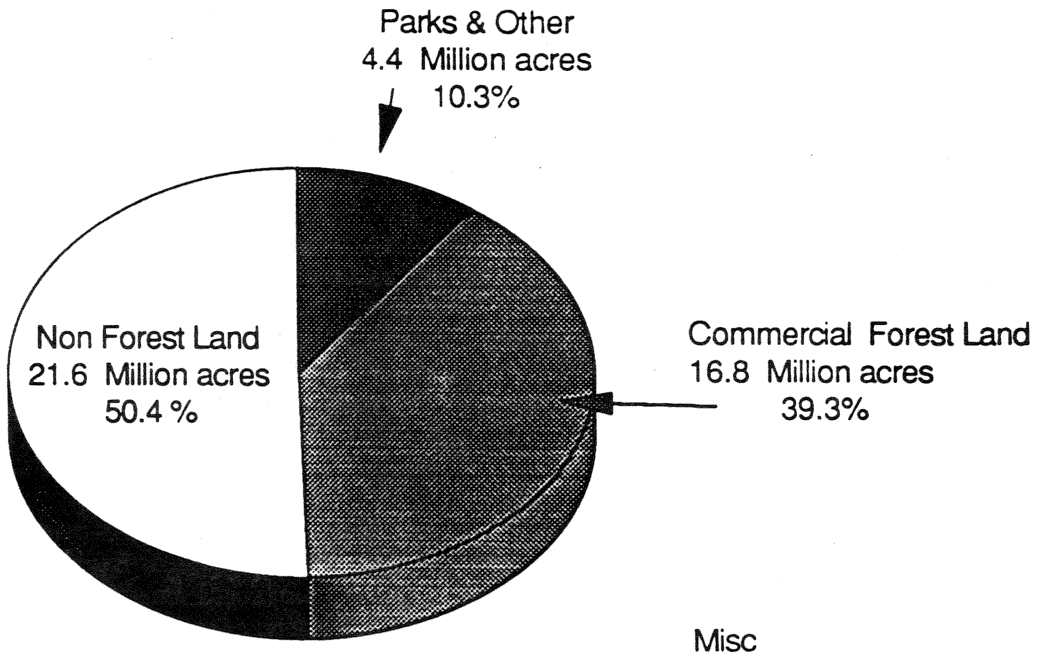
Washington State contains approximately 42.6 million total acres. About 17.6 million, roughly 41 percent, are still forest. Wilderness areas and national parks contain 4.6 million acres of forest which are preserved in perpetuity.

**Figure 3** shows the major owners of commercial forest land in Washington State. Although a major portion of Washington's land is forest, the state has less than four percent of the nation's commercial forest land. However, it contains a disproportionate (14 percent) share of the nation's high-productivity lands, which are capable of producing at least 120 cubic feet of wood per acre per year.

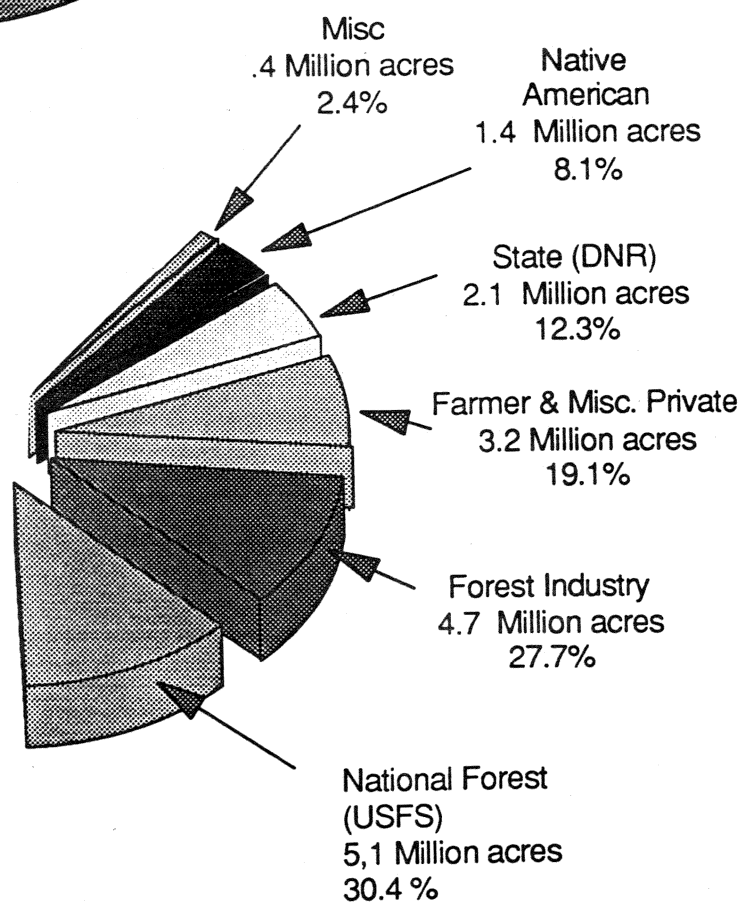
Urban growth also impacts forest land. In the 10 year-period between 1979 to 1989, approximately 170,000 acres (265 square miles) of private forest land in Western Washington changed to rights of ways, residential development and other uses not compatible with forestry. In many cases, the most productive land for forestry is lost, along with the associated loss of wildlife habitat. This trend is continuing as the state's population grows.

**Figure 3**

## Washington State Land Base




## Commercial Forest Land



### 7.3.5 **Natural Resources**

#### 7.3.5.1 Rate of Use and Nonrenewable Resources

The use of minerals in department activities is limited to quarry rock and gravel extraction for road construction. Over time the continued use of these minerals will deplete the resource. Most pit sites, however, are reclaimed when no longer needed and are usually converted back to timber production. Mineral leases are administered by the department's Land and Minerals Division and are not addressed by the Forest Resource Plan.

Resource consumption from fertilization is essentially confined to the raw material and process energy of the fertilizer itself. Urea is the primary fertilizer. Methane (which comes from natural gas) is the major raw material.

Most nonrenewable resources (such as metallic minerals, coal and oil) occur at great depths. They tend to be difficult and expensive to locate. The department's Land and Minerals Division also administers leases for these items; they are not addressed by the Forest Resource Plan.

#### 7.3.5.2 Rate of Use and Renewable Resources

The chief renewable resource on state forest lands is timber. Timber is harvested according to sustainable, even-flow timber calculations. In the 1980s, the department averaged about 30,000 acres of harvest per year. (In 1984, for instance, the department harvested about 29,000 acres. In 1990, however, the figure rose to approximately 37,300, the highest of the past decade. The department estimates that it will harvest about 27,000 acres in 1991.)

## 7.4 BIOLOGICAL EFFECTS

### 7.4.1 **Flora**

#### 7.4.1.1 Numbers and Diversity of Species

The department manages state forest lands in all seven physiographic areas. Approximately 4,000 to 5,000 species of terrestrial plants exist in the state. Many of them are represented on state forest land, providing a wide diversity of species and communities. Because this plan applies to the entire geographic range of the state, a great variety of field conditions will be affected: from wetlands to dry sites; from young, managed stands to old growth; and from steep, rocky sites to low, flat terrain.

There are three components of biological diversity: 1) species diversity; 2) community, also known as ecosystem diversity; and 3) genetic diversity.

Species diversity refers to the richness and abundance of plant and wildlife species within an area. There are two subcomponents of species diversity: richness and equitability. Richness refers to a ratio between the number of species in an ecosystem and the total individuals in the system. Equitability refers to the degree to which the species are equally represented; it is a measure of the relative importance of the species in the ecosystem compared with other species.

Community or ecosystem diversity refers to the many plant communities, forest types and animal habitats over a larger area.

Genetic diversity refers to the maintenance of variability over time among different populations of a species of flora.

The department is committed to consider diversity in managing state forest lands. The department does not see its forests as monoculture, tree-farming plantations. It recognizes that trees are but one component of a complex, diverse ecosystem with many living and non-living parts.

The major factors that affect species number and diversity are discussed below:

1. Succession

Traditional succession concepts depict an orderly progression of plant associations, each modifying existing conditions to a degree that facilitates their replacement by later stages until a stable, climax community results. This succession starts as a weed/forb/grass stage, followed by a shrub-dominated community.

The shrub community is eventually overtopped by tree saplings, usually Douglas-fir in Western Washington. Eventually, a dense, even-aged stand develops that eliminates most understory vegetation. After time, the stand matures to the point where individual trees die or are eliminated by lightning or wind storms. Light begins to penetrate the thick canopy. Later, when openings become large enough, Western hemlock invades. After a long time (400-plus years), the final Western hemlock climax forest develops. (The 400-year period refers to natural succession. Forest management can accelerate this process. The time for a climax species to establish itself on a particular location depends on site-specific conditions and the extent of management activities. Western hemlock, for example, can establish itself as quickly as 20 years after harvest in certain parts of Washington.)